ON THE ORIGIN OF SOME PEGMATITES IN THE TOWN OF NEWRY, MAINE

B. M. SHAUB,

Smith College, Northampton, Massachusetts.

ABSTRACT

The Newry pegmatites described in this paper include a group of four which are located $6\frac{1}{2}$ miles south of Andover, Maine, in the north-east part of the Town of Newry. The relative locations of the particular pegmatites are shown on a sketch map. The principal pegmatite of the group shows a pronounced banding along the hanging wall; the contact band consists of a chilled deposit of fine-grained albite, near oligoclase. The following band consists chiefly of quartz with some intergrown albite and muscovite. The succeeding bands consist of muscovite and albite (cleavelandite). The repetition of albite constitutes a rhythm and belongs to a type of banding believed to be produced by a process of *rhythmic fractional crystallization*, previously proposed by the author to explain certain banded occurrences in fissure veins.

The origin of the pegmatites is credited to a progressive fractionation of single injections of pegmatite magmas separated in time and space. The injections followed the schistosity of the enclosing rock, except in one case where a soda-lithia pegmatite magma was injected along the foot-wall schist contact of an earlier potash type of pegmatite.

There is no evidence to indicate that any of the magmas contained more than 5 to 10 per cent of water or other volatile constituents. Evidences are also lacking to show that the present soda-lithia pegmatites replaced former potash-rich pegmatites; neither are there evidences of any ingress of later hydrothermal solutions. A later soda-lithia pegmatite in contact with an earlier potash pegmatite did not replace any visible part of the latter.

The minor amount of alteration present can readily be accounted for by the reaction produced by the small amount of residual water and other volatiles which no doubt are liberated as highly heated vapors or liquids, which as a consequence are in a very active state and readily affect an alteration of such minerals as spodumene and triphylite.

The pegmatites of the Newry, Maine, locality are located about $6\frac{1}{2}$ miles south of Andover, Maine, and were described in detail by Fraser (1) in 1930, who concluded (1, p. 363) that:

The pegmatite at Newry fails to show any noteworthy banding or zoning of its constituents. A detailed examination of the mineral sequence, however, shows that there is a rather close parallelism, mineralogically, with the pegmatites at Buckfield and elsewhere, as described by Landes. From the structural and textural data available there appears to be sufficient evidence to show that there were at least three definite periods during the formation of the pegmatite. The first and second periods were transitional but the second and third periods were definitely separated by a period of extensive replacement activity which however, was very local in its action. The evidence indicates that the entire process was essentially continuous.

During August, 1936, the writer spent a few days visiting the pegmatites along the western border of Maine and while at the Newry locality he was impressed by the conspicuous banding, Fig. 3, along the hanging wall of pegmatite No. 2 of Fig. 1, the principal pegmatite of the

group. The most striking band consists of very fine-grained albite (near oligoclase) which occurs next to the hanging wall or is separated from the hanging wall at places by an irregular, interrupted band of black tourmaline.
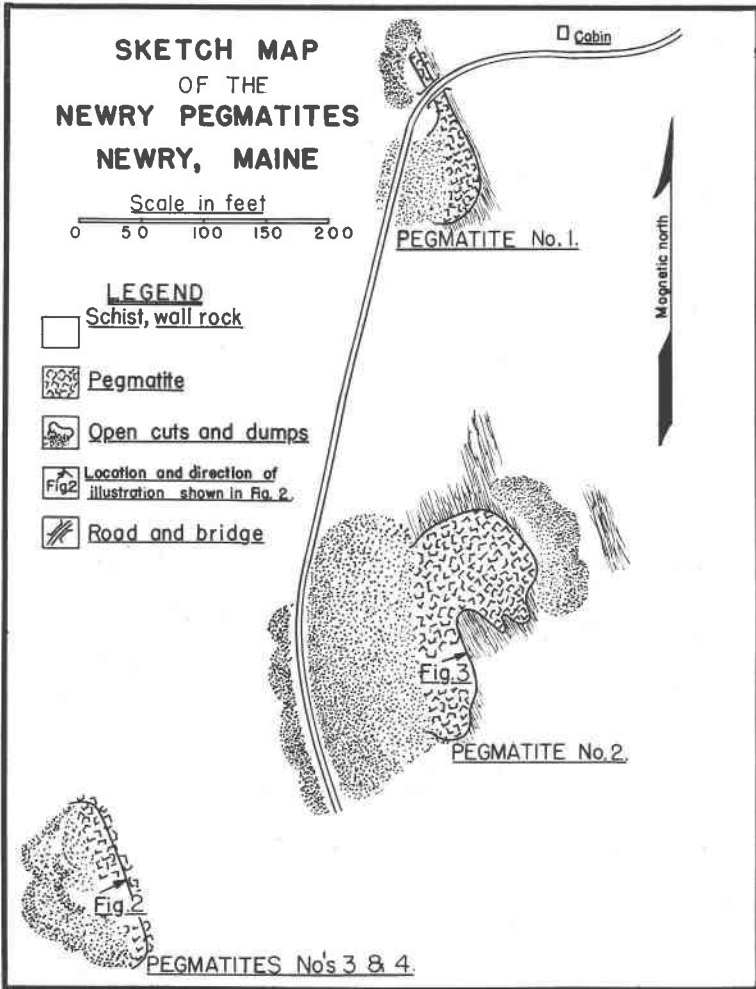

Fig. 1. Sketch map of the Newry pegmatites showing their relative locations.

On account of the unusual occurrence of albite, as a chilled band adjacent to the hanging wall, together with other specific relationships of the minerals which did not appear to harmonize with the paragenesis

given by Fraser (1, p. 352), the pegmatites were revisited on two later occasions.

The Newry pegmatites included in this discussion consist of the two described by Fraser and two additional ones which occur together in a small quarry located several hundred feet to the south and west of pegmatite No. 2. The latter are designated as pegmatites Nos. 3 and 4 on Fig. 1. It could not be definitely determined from Fraser's paper if he described material from pegmatites 3 and 4.

The strike and dip of the pegmatites of the group conform in general to the strike and dip of the schistosity of the enclosing rock. The schist consists essentially of muscovite, biotite and light green actinolite (Fig. 7). In addition it contains a very small amount of quartz which occurs in minute grains very sparsely scattered throughout the rock.

As pegmatite No. 1, Fig. 1, did not appear to contain any specially important evidence on the origin of soda-lithia pegmatites and on the nature of pegmatite magmas, it will not be further considered at this time. It does, however, contain a suite of soda-lithia minerals and it is probably more closely related mineralogically to pegmatite No. 4 than to either No. 2 or No. 3.

Pegmatite No. 2 is most replete with evidences concerning its origin and hence the writer will outline, in more-or-less detail, a theory of origin based on the evidences most clearly revealed by this pegmatite. The banded hanging-wall portion shown in Fig. 3 is well developed, while the contact band of chilled albite is especially noteworthy. Throughout the pegmatite the radial structures developed especially by the cleavelandite, as shown in Figs. 4 and 6, provide abundant examples of the progress of the crystallizing soda-lithia-cesia-rich pegmatite magma.

DESCRIPTION OF THE BANDING ALONG THE HANGING
WALL OF PEGMATITE NUMBER 2

The first deposition consists of an irregular, discontinuous crust or band of black tourmaline which is of a deep indigo color in thin section, and which also occurs as "suns," irregular clusters, and as individual crystals in the schist. The latter feature is a common one associated with other pegmatites, whether potash- or soda-rich types, hence it does not appear to offer any critical criteria pertaining to the origin of soda-lithia pegmatites. The first material to be desposited in sufficient quantity to develop a continuous band along the hanging wall, where exposed, consists of a very fine-grained albite, near oligoclase, Fig. 8, which forms a band up to three inches thick. The portion of this band nearer the wall has a more or less equidimensional fine-grained texture. The grains may show many fine or only a few twin lamellae or they may be without ap-
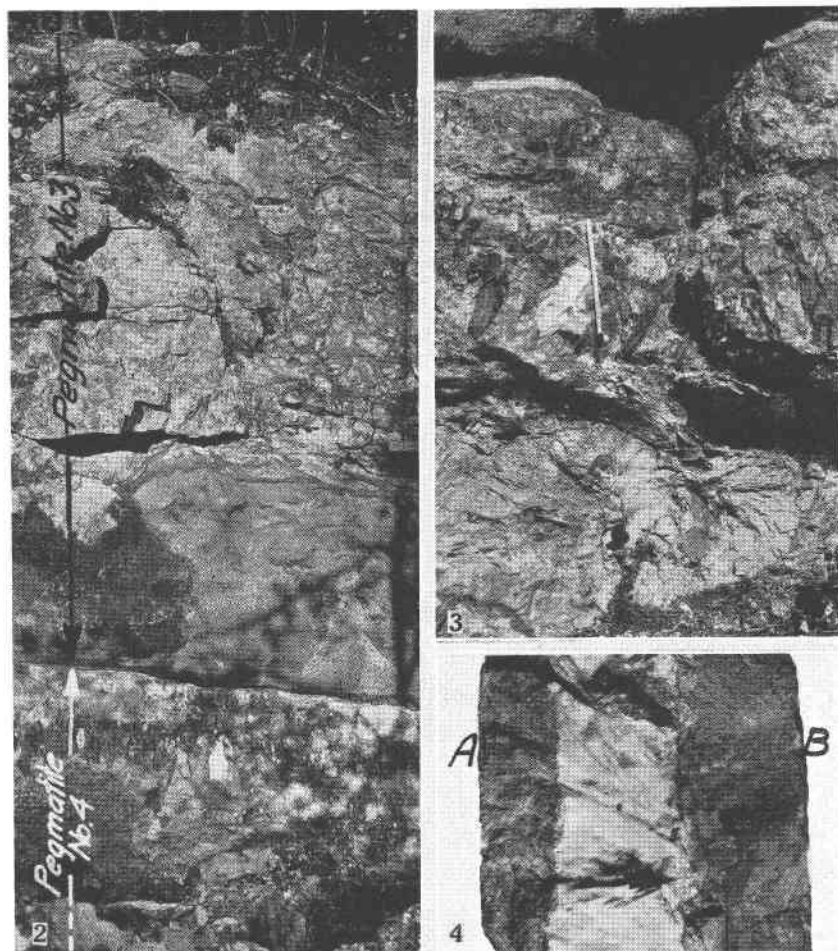
Fig. 2. A portion of the face of pegmatites Nos. 3 and 4. Note the fine-grained contact zone at the base of pegmatite No. 3 and the narrow radial band of muscovite near the top of pegmatite No. 4.

Fig. 3. A portion of the hanging wall section of pegmatite No. 2. The narrow chilled band of albite is clearly shown near the top in contact with the schist. The following band consists largely of quartz which is followed by a band of muscovite. Beneath the muscovite is cleavelandite. The scale across the muscovite band is extended 12 inches.

Fig. 4. A section of a part of two parallel spodumene crystals, containing a band of cleavelandite which grew normal to the adjoining surfaces of the crystals. Like bands of cleavelandite were also attached to the surfaces A and B, but these broke away in handling the specimen.

parent polysynthetic twinning. The shape of the grains near the succeeding band becomes more elongated or "platy," and they begin to show an orientation normal to the band. The second band, up to twelve inches in thickness, consists largely of quartz with intergrown albite and muscovite.

It is not improbable that the second band, with some difference in mineral composition, would have been the first band to crystallize if the wall rock had contained an abundance of quartz so that the quartz could have rendered a "seeding out" effect. Hence, the character of the wall-rock may, under certain physico-chemical conditions, make a decided mineralogical and textural difference in the contact crust.

The third band to form is up to sixteen inches thick and consists largely of long blades of muscovite normal to the wall. The size of the muscovite blades increases with the development of the band, a phenomenon common and probably always present in crystallized mineral crusts (2). Some quartz and cleavelandite crystallized along with the muscovite.

During the crystallization of the preceding albite and quartz bands, very little potassium and water could have been removed from the pegmatite magma by crystallization of the earlier non-hydrous minerals, and the dense, compact, fine-grained albite band must have provided an effective impermeable barrier between the hanging-wall rock and the crystallizing magma. Hence, the water contained in the outer part of the magma was accumulating at the interface between the advancing crusts and the remaining magma. Consequently the composition of the fractionating pegmatite magma became richer in water as well as potash which resulted eventually in a composition and a degree of supersaturation at the interface which caused the precipitation of muscovite. In the absence of much water, other physico-chemical conditions being equal, one may expect that microcline would occur in place of the muscovite band, or it may be deferred to a position nearer the center of the pegmatite mass, depending of course on the amount of K_2O present. The result of a fractionation of this kind may account for the occurrence of microcline nearer the foot wall, as the water of the pegmatite may have been more concentrated toward the hanging wall side. It is probably very rarely that a pegmatite magma has previously undergone sufficient fractionation to eliminate enough potash to prevent the formation of at least some potash feldspar.

The muscovite band was followed by another band of albite; this time the albite developed the characteristic bladed variety known as cleavelandite. At the contact with the preceding band of muscovite the blades of cleavelandite are predominantly smaller, and normal to the earlier bands. The cleavelandite blades increase in size to a maximum as the

distance from the contact increases. As crystallization progressed the temperature conditions became more uniform throughout the pegmatite as the loss of heat was not as rapid and numerous centers of crystallization were initiated by other minerals such as beryl, spodumene, triphylite, tourmaline, etc. From these minerals as centers of attachment the succeeding cleavelandite formed radiating structures as shown in Figs. 4 and 6. The further crystallization of the albite, which constitutes more than half the total quantity of the minerals, followed a random orientation and continued in this manner until crystallization was complete, except for the crusts of albite in the few small cavities where the albite formed a final crust pointing to the center of the cavity.

The banding in contact with the schist is an asymmetrical banding, for that along the foot wall is not a repetition of the banding along the hanging wall. The band along the foot-wall is up to a foot or more thick and consists essentially of medium fine-grained albite. This is followed without sharp demarcation by cleavelandite, of gradually increasing coarseness, which continues into the body of the pegmatite.

Fraser (1, p. 351) states that:

> Mr. Butterfield, who visited the quarry in 1927, reported that a layer of microcline about eight inches thick occurred along the foot-wall.

No such band was observed by the writer; however, along with the cleavelandite some distance from the foot-wall a few irregular masses of microcline were observed. It is probable that microcline was more abundant and that considerable commercial microcline may have been removed during mining, however, the principal minerals sought were pollucite, amblygonite, and spodumene.

The visible contacts of the microcline masses with the cleavelandite revealed an intergrowth of the two minerals, as shown in Fig. 5.

It is quite certain that the microcline is considerably later than the first deposition of albite along the foot-wall schist, for as one follows the progress of crystallization away from the fine-grained contact band, or zone of albite, the succeeding albite becomes bladed and has developed blades up to 6 inches or more in length before the microcline began to crystallize. The crystallizing microcline developed around and from the projecting blades of cleavelandite, while at a later time the cleavelandite which continued to crystallize grew away from the microcline when the potash was depleted or reduced below the composition for microcline to continue to form.

The presence of sub- to euhedral crystals of albite within the microcline, Fig. 9, suggests that these were engulfed by the crystallizing microcline and they now represent a poikilitic texture of albite in microcline.

This relationship would be expected from a pegmatite magma in which the vastly more abundant soda-feldspar was simultaneously crystallizing with the microcline.
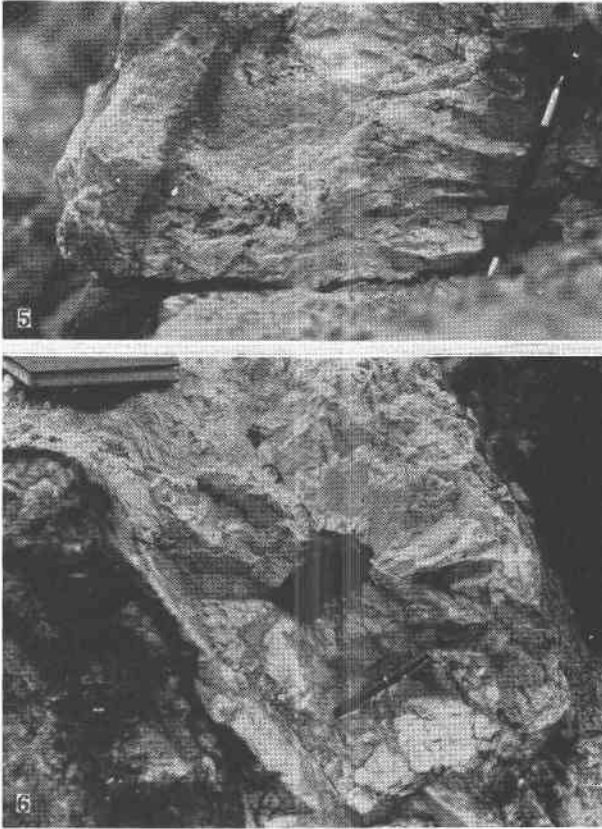

Fig. 5. A specimen of microcline showing, at the right, an intergrowth with cleavelandite.

Fig. 6. A radial growth of cleavelandite about an earlier mass of triphylite, now stained black by manganese oxides. Similar radial growths of cleavelandite are frequent about spodumene, beryl, tourmaline, and other minerals scattered at random within the body of the pegmatite.

The illustration of this intergrowth, Fig. 5, shows oriented blades of cleavelandite on the right intimately associated and intergrown with microcline on the left. This or similar relationships between bladed and massive minerals has been interpreted as being due to the replacement of the massive mineral by the bladed species (3).
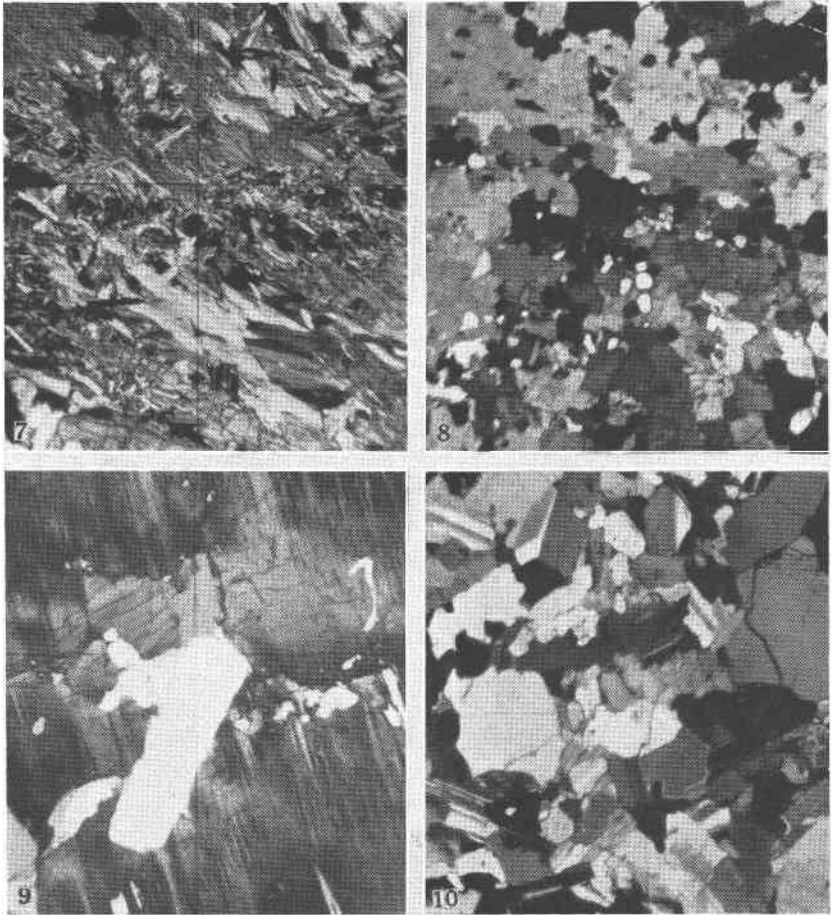
Fig. 7. Section of schist wall rock showing the oriented grains of muscovite, biotite, and actinolite. Quartz is absent in this portion of the section. ×16

Fig. 8. A section of the chilled albite band of Fig. 3 showing the fine-grained texture near the hanging-wall contact. ×16

Fig. 9. Section of microcline showing irregular grains of albite (white) included within the microcline. ×16

Fig. 10. A section of the granular contact rock along the foot-wall of pegmatite No. 3. ×16

Rhythmic Fractional Crystallization

The deposition of albite a second time in the hanging-wall series of bands constitutes a rhythm. The development of the banded structure with its increasingly coarser texture from the wall as described above and shown in Fig. 3 can be explained most logically by the process of

rhythmic fractional crystallization, first proposed by the writer (2, p. 396) to account for the recurring bands of the same mineral species in filled-fissure veins. This occurrence of rhythmic fractionation appears to be the first definite example of the kind observed in a pegmatite and well supported by the mineralogical and textural relationship of the bands and their relationship to the wall rock. Fraser's description of "The Newry Pegmatite" makes frequent references to the recurring deposition of minerals. Among some of his statements are (1, p. 353):

> . . . many minor reversals of sequence are to be observed among the Newry minerals; quartz, for example, recurs many times in the general sequence. The recurrence of a mineral later in the general sequence, is further evidence of fluctuations in conditions of the depositing solutions and could hardly be considered as due, in all cases, to the ingress of fresh solutions.

> (1, p. 354) Certain minerals, for example, lepidolite or quartz, recurred at numerous periods during the deposition. The frequent recurrence of these minerals probably indicates a local supersaturation of the solution . . .

> (1, p. 359) In several specimens a layer of lepidolite was formed around a tourmaline crystal and in one specimen there were *several alternating layers of lepidolite and quartz* around a tourmaline crystal. (Italics are Shaub's.)

This last observation of Fraser's is apparently another excellent example of rhythmic fractionation and undoubtedly occurred rather deep within the body of the pegmatite.

Some Previous Views on Oriented Mineral Growths in Pegmatites and Their Interpretations

Hess (3, p. 291) states that

> much has been made of comb and concentric structures in the solidifying pegmatites. That these exist there is no doubt and they have been explained by crystallizing first along the walls and in successive layers inwards. This feature may be overemphasized, however.

Hess, in the same paper, after thus disposing of the crustified relationships of pegmatite minerals, uses the penetrating relationship between bladed and massive mineral aggregates to establish an earlier crystallization of the latter. The penetrating bladed species are often placed in paragenetic tables as being later than the surrounding or enclosing minerals. In the writer's studies of fissure veins and pegmatites he has found no evidence to support this view, much less the general application of the phenomenon to establish a theory of widespread, extensive and at times almost complete replacement of entire pegmatites. Schaller (4) has also postulated the complete replacement of earlier pegmatites by later solutions thought to be of probable hydrothermal character. Ellsworth (6, p. 329), however, describes an order of crystallization, similar to that proposed by the writer for the No. 2 Newry pegmatite, for some

soda feldspar, microcline, and quartz pegmatites in Ontario. He writes:

along the sides next to the wall rock there is a varying width of soda feldspar up to two feet wide along the hanging wall, less along the foot-wall. This is a common, typical arrangement in Ontario pegmatites and would probably be interpreted by most observers as indicating that the soda feldspar crystallized first, the microcline next and finally the quartz.

This brief description suggests a process of crystallization from a pegmatite magma having a composition, except for the fugitive constituents, like the now existing pegmatites, instead of a process in which the soda feldspar replaced an earlier potash feldspar or a graphic-granite which existed between the remaining microcline and wall rock.

PARAGENESIS OF THE MINERALS OF PEGMATITE NO. 2

The order of crystallization as shown in Fig. 11 is based chiefly on observations of material within the quarry and still in place in the pegmatite, or from material on the dumps, or from specimens obtained from the late W. D. Nevel who operated the quarry during the time it produced the many interesting and attractive mineral specimens.

Fraser (1, p. 352) divided the minerals in groups after the grouping of Landes (5). This arrangement seems to the writer to be an unnatural grouping of the minerals of the Newry pegmatites, for he has not found any evidence for making the group distinctions with the exception of the late alteration products which have long been recognized as being secondary. There are variations in the appearance of the same mineral, but such variations are continuous and are to be expected as a pegmatite magma crystallizes with accompanying ever-changing physico-chemical character of the uncrystallized part of the magma still fluid, and continually becoming richer in volatile substances as it reaches the more or less central part of the pegmatite body.

By far the larger quantity of material present in the pegmatite is cleavelandite, and this mineral, with some variation in composition crystallized from the beginning to the end of the period of crystallization, and is certainly magmatic in so far as the originally injected igneous material is magmatic. This long period of crystallization for soda feldspar is not common, even in soda-lithia-cesia-rich pegmatites. Although the soda feldspar may or may not have been slightly preceded at the start by black tourmaline, the total amount of such tourmaline was comparatively small. Quartz and muscovite appeared early and continued in small quantities throughout the consolidation period, the latter becoming richer in lithia as deposition progressed. Microcline also appeared early, but only after a considerable amount of cleavelandite had crystallized.

The minerals, beryl, spodumene, triphylite, and some tourmaline began to appear scattered throughout the pegmatite after approximately a fourth to a third of the magma had solidified, or possibly somewhat earlier. These minerals thus frequently provided a support for cleave-

DIRECTION OF FRACTIONATION WITHIN PEGMATITE NO. 2, FIG. I.

WALLROCK

MAGMATIC STAGE

HYDROTHERMAL END PHASE (CAVITY MINERALS)

ALTERATION OF PRIMARY MINERALS

black — Tourmaline — pink blue green

Albite

fine grained — Cleavelandite

contact band

Quartz

Muscovite becoming richer in lithium

Microcline

Spodumene

Beryl becoming richer in caesium

Triphylite and lithiophylite

Microlite

Zircon

Apatite

Lepidolite

Cassiterite

Pollucite

Amblygonite

Beryllonite
Siderite
Eosphorite
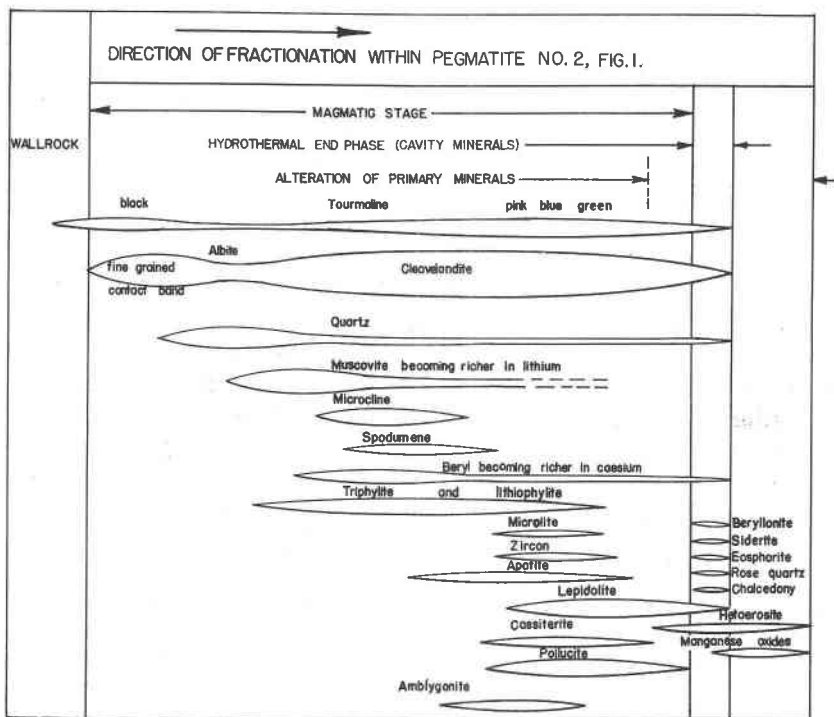Rose quartz
Chalcedony
Hetaerosite
Manganese oxides

Fig. 11. Diagram showing the paragenetic relationship of the more abundant minerals of pegmatite No. 2.

landite which often produced radial suns about them as centers, as shown in Figs. 4 and 6. Apatite is frequently associated with triphylite as a partial crust and is somewhat later, although close in time of deposition. Lepidolite with characteristic lavender color did not appear until toward the end of crystallization, and is often intimately associated with cleavelandite, while the latter contains, or is associated with, the rarer minerals as microlite, zircon, cassiterite, pollucite, amblygonite, etc., often in a contemporaneous intergrowth. This last association apparently represents the very near-end phase of crystallization when the small amount of water originally present in the magma became more abundant on account of fractionation of the less soluble constituents. The residual water of the pegmatite magma together with mineral matter then in

solution in the water, caused the development of the small crystal-lined cavities or vugs which occur sparingly scattered through a large part of the pegmatite.

The rôle of the small amount of residual water in pegmatite magmas is believed by the writer to be a most important one and to often produce profound effects after some particular phase is reached.

One of the minerals prone to be affected by the residual highly heated water either as a liquid or vapor, or as a phase above a critical point, is spodumene, which in some pegmatites occurs only as completely altered pseudomorphs, or as a core of spodumene with a shell of alteration products. In the Newry pegmatite such profound alteration is absent as the spodumene is comparatively fresh. Another lithium-bearing mineral to be easily affected is triphylite which alters to hetaerosite and manganese oxides. The triphylite throughout the pegmatite has been considerably altered even where all the other minerals appear to be perfectly fresh, Fig. 6. This is probably due to the readiness with which the gaseous water can permeate the cleavelandite of bladed texture and the ease of alteration of the triphylite. As the alteration of the triphylite in the deeper parts of the quarry does not seem to have resulted from surface waters, it appears that the alteration may have started even before the development of the cavity minerals and continued to the present, especially where triphylite is locally exposed to surface conditions.

The textural and mineralogical relationships indicate that the crystallization proceeded within a *closed system*, except for a very brief period at the start due to the porosity of the wall rock, and continued progressively by fractionation from a single injection of a soda-lithia-cesia-rich pegmatite magma. There appears to be no evidence of later solutions of any kind being added to the original pegmatite magma.

Description of Pegmatites Nos. 3 and 4

Pegmatites 3 and 4 occur in the same quarry and to many observers would appear as a single pegmatite. The face of the quarry is illustrated in Fig. 2 which shows a fine-grained portion near the center of the elevation and dipping at a low angle to the right—south. The bottom of this fine-grained band marks the bottom of the granitic contact phase of pegmatite No. 3, and also its contact with the wall rock before the injection of pegmatite No. 4 along the footwall contact. The geologic relationship of pegmatite No. 2 to pegmatites 3 and 4 could not be determined on account of the overburden between the two quarries.

Pegmatite No. 3 is a typical potash-rich pegmatite containing chiefly potash feldspar, black tourmaline, muscovite, and quartz with some coarse graphic granite.

The magma of pegmatite No. 3 was sufficiently superheated to produce a reaction with the country rock forming the granite-like reaction or contact zone, Fig. 10. This contact rock is friable, and difficult to make into thin sections. Three sections of the material analyzed by the Rosiwal method contained an average of 43.9% quartz, 5.8% microcline, 40.2% oligoclase, 8.9% muscovite, 1.2% sphene, 0.1% apatite, and a little black tourmaline.

Following upward from the fine-grained contact rock the pegmatite proper consists of a medium grain, for a pegmatite, which becomes somewhat coarser, but not markedly so. There is some muscovite oriented normal to the contact zone but it is not conspicuous, probably because there is not a large percentage of the mineral present. Also probably because the magma was sufficiently superheated to produce a large mass of highly heated contact rock, as well as to heat the adjoining wall rock to the extent that the heat from the pegmatite proper was not removed sufficiently fast during the period of crystallization to produce marked crustification. Further, water in solution is necessary to produce muscovite.

Pegmatite No. 4 is a more or less typical combination of some potash with abundant soda and lithia minerals. The pegmatite magma was not sufficiently rich in soda to initiate the precipitation of albite, as in pegmatite No. 2. The potash feldspar was first to crystallize in a rather fine-grained deposit in the hanging wall portion attached to the foot wall contact rock of the overlying pegmatite, which had already cooled down sufficiently to somewhat "chill" the magma along the contact of pegmatite No. 4 as it was injected along the fine-grained contact phase of pegmatite No. 3 and the wall rock. A rather pronounced band of muscovite followed the fine-grained border of the lower pegmatite, and this in turn was followed chiefly by coarser grained potash feldspar and quartz. At the foot of the face, the dump material partly covers the central part of the later pegmatite No. 4 which at this point consists of cleavelandite, having rather coarse intersecting blades thus forming openings or "cavities," having polyhedral angles, which frequently contain the rare phosphate eosphorite. Several large crystals of spodumene are visible but these have undergone alteration and are valueless as a source of lithia. The coarse porous nature of the cleavelandite would suggest a greater abundance of residual water than that associated with pegmatite No. 2, and as a consequence a greater hydrothermal attack and leaching, at or near the end of the period of deposition, of the earlier less stable minerals like spodumene.

It is interesting to note that the soda-lithia rich magma of pegmatite No. 4 did *not* react with the earlier overlying potash-rich pegmatite pro-

ducing extensive replacement. Instead, each pegmatite shows clearly that it was derived from a single injection of a pegmatite magma which in all probability, except for the fugitive constituents, had a composition essentially like that of the now existing pegmatites; each having crystallized according to the solubilities of their respective constituent minerals in the residual pegmatite magma as the temperature dropped due to loss of heat to the surrounding rocks.

The Probable Nature of the Pegmatite Magma

The evidence given above indicates that the magma of pegmatite No. 2 arrived in a single injection and that it had a composition essentially the same as that of the body of the solid pegmatite, except for the escape of a part of the volatile constituents not incorporated in the structure of the minerals during crystallization. The amount of such volatile constituents that escaped is probably of the order of 5 per cent, or even less, rather than that the pegmatite-forming solutions were "hydrothermal." The writer finds too many objections to an origin of the soda-lithia rich pegmatites by a "long continued flow" (3) or by "waves" (5) of hydrothermal solutions.

The temperature of the magma of pegmatite No. 2 was probably not much above the temperature of crystallization of the albite in the contact bands and the wall rocks were also probably at a considerably lower temperature, otherwise the contact bands would not be so fine grained for a soda-lithia pegmatite. The presence of an abundance of water or other gases would have exerted considerable influence on developing a coarse-grained contact and if accompanied by a high degree of superheat, a contact reaction zone with the wall rock would undoubtedly be present as in some other pegmatites.

The absence of a large volume of cavities in the body of the pegmatite shows that any large volume of volatile substances could not have been trapped within the pegmatite magma by the quick consolidation by the peripheral part of the magma into a very dense fine-grained envelope along the contacts.

If one were to follow the paragenesis of Fraser who in turn had followed the grouping of Landes, and placed the soda feldspar later than the microcline, one would have to assume that the early potash feldspar, tourmaline, etc., of Landes' Group I, originally in contact with the walls, had been completely replaced by highly heated aqueous solutions, and then later conditions would have to change sharply to one which would deposit a fine-grained band on the foot wall and a still finer-grained chilled band on the hanging wall. In the interval of dissolving out the preceding pegmatite and the crystallization of the present one, a large

cavity filled with hydrothermal solutions would have had to exist in the schist. As the schist does not show effects of solution, the removal of material would have had to stop at the wall rock, which is inconsistent, for the wall rock should be equally as soluble as muscovite, potash feldspar, quartz, tourmaline, etc., of the supposedly original pegmatite. It is also unlikely that the hanging wall of the schist could have supported itself under such conditions and xenoliths of schist would be expected to be present on the floor in the later soda-lithia pegmatite. If the microcline masses represent residuals of replacement they too should have gravitated to the foot wall and occur only in the foot wall part of the present pegmatite, and they should be surrounded in part, at least, by fine-grained albite just as in the case of the foot-wall schist. Such is not the case for the microcline masses are not anywhere to be seen in contact with the foot wall.

In pegmatites 3 and 4 the conditions of the contacts indicate clearly that the overlying pegmatite No. 3 had already cooled to an appreciable extent before the magma of the lower potash-soda-lithia pegmatite No. 4 was injected. The contact between pegmatites 3 and 4 shows that the material of the later magma did not replace the contact phase of the earlier and overlying pegmatite, neither did it replace any visible part of the earlier potash pegmatite, but, instead a medium fine-grained border or band was deposited and this was followed in places by a band of muscovite having the crystal blades oriented normal to the contact, and they also show a normal directional growth, away from the wall, as crystallization progressed. The relationship of these two pegmatites also shows clearly that in this case at least, and probably in the majority of cases, if the facts were known, the successive pegmatite magma fractions upon being injected into the surrounding schists and gneisses, find a channel of least resistance within the schist or along the contact of the schist and an earlier pegmatite, or other structural weakness rather than within the body of an earlier and consolidated pegmatite. The extremely irregular and lenticular shape of pegmatites in general indicates that the channels through which the pegmatite magmas have passed, undoubtedly have been closed below the large lenticular masses by quick consolidation of the small masses and stringers of magma, that remained within the narrow passages or feeders; for these small masses would freeze very quickly, in general, as is shown frequently by the contact phases of many of the larger pegmatites, hence repeated injections of pegmatite magmas would be expected to produce separate pegmatites of slightly different age and composition.

In a brief statement regarding the origin of the phosphate minerals

from the pegmatites at Poland, Newry, and Buckfield, Maine, and also at Branchville, Connecticut, Berman and Gonyer (7) state that:

This remarkable similarily of four localities at which lithia-pegmatites have been studied seems to require a closed system, with no ingress of new material into the pegmatite solutions.

Conclusions

From the foregoing description of the structural and textural characters of the minerals of pegmatites Nos. 2, 3 and 4, it seems that these pegmatites originated by the crystallization of single injections of pegmatite magmas. It is certain that the quarry farthest to the southwest in the area is divided into two distinct pegmatites, one overlying and in contact with the other. It is also evident that the soda-lithia-rich magma of the lower one, No. 4, did not in any way react with or replace any visible part of the earlier overlying potash-rich pegmatite.

The evidences found in these pegmatites do not in any way lend support to the replacement theories for the origin of pegmatites rich in soda-lithia- and cesia-bearing minerals.

The writer is indebted to the late W. D. Nevel for many courtesies while studying the Newry pegmatites.

References

1. FRASER, H. J., Paragenesis of the Newry pegmatite, Maine: *Am. Mineral.*, **15**, 349–364 (1930).
2. SHAUB, B. M., The cause of banding in fissure veins: *Am. Mineral.*, **19**, 396 (1934).
3. HESS, FRANK L., The natural history of the pegmatites: *Eng. and Min. Jour.*, **120**, 289–298 (1925).
4. SCHALLER, W. T., The genesis of lithium pegmatites: *Am. Jour. Sci.*, **10**, 269–279 (1925).
5. LANDES, K. K., The paragenesis of the granite pegmatites of central Maine: *Am. Mineral.*, **10**, 355–411 (1925).
6. ELLSWORTH, H. V., Euxenite-polycrase from Mattawan Township, Nipissing District, Ontario: *Am. Mineral.*, **11**, 329–334 (1926).
7. BERMAN, H., AND GONYER, F. A., Pegmatite minerals of Poland, Maine: *Am. Mineral.*, **15**, 375–387 (1930).